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A New Radio-Active Element, which Evolves Thorium Emanation. Preliminary Communication.

By O. Hahn, Ph.D.

(Communicated by Sir William Ramsay, K.C.B., F.R.S. Received March 7,—Read March 16, 1905.)

[The material for this investigation was provided by Sir William Ramsay; it was the final residue remaining after fusion with bisulphate of 5 cwt. of the cubical ore from Ceylon, for which the name "thorianite" has been suggested by Professor Dunstan. This residue was fused with carbonates, the silica was removed, and the carbonates dissolved in dilute hydrochloric acid. Lead was precipitated as sulphide, and the carbonates again precipitated. These preliminary operations were carried out by Mr. Charles Tyrer and by Dr. Denison.]

This residue weighed about 18 grammes, and a preliminary estimation of radio-activity led to the belief that it would yield about 15 milligrammes of pure radium bromide. The carbonates were dissolved in pure aqueous hydrobromic acid, and the bromides fractionated according to Giesel's method. But difficulties were soon encountered; the more soluble portion did not fall off in radio-activity, but gradually grew more strongly radio-active; the radium concentrated at the least soluble end, and the middle fractions became relatively weak in radio-activity.

Small traces of iron and other impurities, unavoidable in London, collected in the more soluble portions, and the ferric bromide imparted to them a brownish-yellow colour. These, and indeed all fractions, were again treated with hydrogen sulphide, and a minute quantity of a peculiar dark-brown precipitate came down. It was also radio-active; it was soluble in nitric acid to a pale green solution, and on evaporation crystals of two kinds deposited; easily soluble green crystals and less soluble white ones. The investigation of these bodies is still in progress.

By a series of troublesome operations, a quantity of precipitate was obtained by aid of ammonia, and to separate iron, it was treated in acid solution with ammonium oxalate; this produced about 10 milligrammes of crystalline precipitate, which was by far the most active preparation obtained, and which shows after two months no diminution in its radio-active power. It glows feebly in the dark, and imparts bright luminosity to screens both of platino-cyanide and zinc sulphide. If a current of air be blown through a solution of this substance and directed on to a screen coated with zinc

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sulphide, luminosity is produced, which, nevertheless, is different in intensity from that shown when a similar experiment is performed with Giesel's emanium. The phenomena are not so brilliant as those obtained from a strong sample of emanium kindly sent by Professor Giesel. It was not possible to perform the beautiful experiment of allowing the emanation to pour down on the screen and blowing it away, probably because the new substance emits β-rays in too great abundance. But that the dry substance also evolves emanation was easily discovered by help of an electrometer.

The first impression, that the new substance was identical with actinium or emanium, was found to be untenable,* for the new preparation evolves an emanation identical with that of thorium; different samples gave for the half-period of decay from 52 to 55 seconds; for the half-period of the induced activity, somewhat more than $11\frac{1}{2}$ hours was found, and a small remaining activity persists and decays very slowly. (The half-period for thorium emanation was found by Le Rossignol and Gimingham† to be 51·2 seconds; Bronson, working in Rutherford's Laboratory, found 54 seconds.) As this phenomenon has up till now not been noticed with thorium emanation, it may be conjectured either that another radio-active substance is mixed with the new body in very small traces, of which the induced radio-activity must have a long period of decay, or what is less probable, that the induced activity of thorium, like that of radium, changes into another product with a long radio-active existence. It is certain that radium emanation and also Rutherford's radium-E were absent.

The oxalate, which weighed 10 milligrammes, dissolved in hydrochloric acid, gave a quantity of emanation considerably greater than would be evolved from a kilogramme of thorium in solution; consequently, it is more than 100,000 times as active as thorium. Further work has resulted in the accumulation of 20 milligrammes of material nearly 250,000 times as active as its own weight of thorium nitrate. Thorium itself, if present at all, must be there in minimal quantity, for the oxalate gives tests for calcium for the most part. Whether this active substance is a constant radio-active constituent of thorium preparations, or whether it is another new radio-active element, remains still undecided. Its quantitative extraction from thorium salts has not yet been investigated. After precipitation of a small part of

* The measurements of the emanations and excited activities were carried out in collaboration with Dr. Sackur, working in this laboratory; we also re-determined the half-period of decay of the emanation from Giesel's emanium, as about three seconds, and for its induced activity a period of about 36 seconds. More exact measurements are in progress.

† 'Phil. Mag.,' July, 1904, p. 107.

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the solution in hydrochloric acid of the original ammonia precipitate with ammonia, the filtrate shows considerable radio-activity, which rapidly falls off in a few days, but does not wholly disappear, and the removal of this substance does not diminish appreciably the radio-activity of the insoluble residue. Whether that is due to thorium—x or not has not yet been quantitatively investigated. The close relation of the new body to thorium is proved, not merely by the apparent identity of the two emanations, but also in its having been separated from a mineral unusually rich in thorium.*

We are in hopes that it may prove possible, by several processes of concentration, to obtain an even more strongly radio-active product, and to be able to describe more in detail the chemical properties of the substance; one difficulty consists in the adhesion of the substance to all precipitates; all filters are radio-active, and can hardly be purified by repeated washing. The activity of the sulphide precipitate may, perhaps, be due to this cause; the emanation which it yields appears to be identical with that obtained from the precipitate with ammonia.

Recent researches would appear to show that this substance is present in soil in amount comparable with, but still considerably smaller than radium. G. A. Blanc† has described in a paper on "the Radio-Activity of Mineral Springs," a gas which contains thorium emanation. N. M. Dadourian,‡ in investigating the radio-activity of subterranean air, has detected not only radium emanation, but also that of thorium; and Elster and Geitel§ have described a preparation obtained from the mud from the Baden Baden "Ursprung" as containing no thorium in detectable quantity, but yet evolving thorium emanation in amount such that half a gramme of thorium oxide would be required to produce it. They conjecture, therefore, the presence of a new radio-active element. Attention may also be called to the fact that inactive thoria is said more than once to have been obtained.

It is almost certain that all these emanations are the product of this new substance, and are not derived from thorium itself, for the amount of emanation obtainable from thorium is so small that, if it can be measured at all, it should be possible to detect thorium analytically in the source from which it is evolved.

* Experiments are in progress in this laboratory to attempt to concentrate the radio-active substance from a large quantity of thorium; but, so far, no definite results have been obtained.

† 'Phil. Mag.,' vol. 9, pp. 148 to 154.

‡ 'Sill. Amer. J. of Science,' vol. 19, 1905, pp. 16 to 22.

§ "Radioaktivität der Sedimente der Thermalquellen," 'Chem. Centralbl.,' 1905, vol. 1, p. 651.